Structures

Ron Mader
Mechanical Manager
NRL
202-404-3470
rmader@space.nrl.navy.mil

Mission Requirements (1 of 5)

3.2 Performance Requirements and Physical Characteristics

- **Mass Properties**
  - **Mass Properties Shall Be Defined, Reported, and Controlled to Preserve the Performance Margins As Specified in the Flight Vehicle to Launch Vehicle ICD**
- **Dimensions and Envelope**
  - **The Launch Configuration Shall Be Compatible With the 3 Meter (10 Foot) Diameter Delta II Fairing in the Three Stage Configuration. The Dimensional Envelope Constraints Shall Consider All Combinations of Dynamic and Thermal Environments Encountered**
- **Coordinate System**
  - **As Defined by Figure 1**
- **Maintainability**
  - **Flight Hardware Shall Be Designed for Service and Access, Where Practical. Positive Positioning and Alignment Features Shall Be Provided**
- **Systems Effectiveness Models**
  - **An Analytical Model Shall Be Developed That Correlates the Structural Modes to Within 5 Percent of Experimental Results. The Analytical Model Should Be Written in NASTRAN or Equivalent**
- **Environmental Conditions**
  - **The Spacecraft Shall Be Designed to Operate Within Specification Limits During and After Exposure to All Operating and Non-operating Environments**

Mission Requirements (2 of 5)

3.3 Design and Construction

- Outgassing
  - Materials Shall Be Selected for Low Outgassing Characteristics, Using the Requirements That Meet the Requirements of SP-R0022 for Outgassing. Materials Exhibiting Total Mass Loss (TML) of 1.0 % or Less and Collected Volatile Condensable Material (CVCM) Values of 0.1 % or Less Shall Be Used
- Structural and Metallic Materials
  - Metallic Materials Shall Be Corrosion Resistant by Nature or Shall Be Corrosion Inhibited by Means of Protective Coatings. Base Metals That Form Galvanic Couples Shall Be Plated With Materials That Reduce the Galvanic Potential
- Magnetic Materials
  - Use of Magnetic Materials Should Be Avoided Whenever Possible
- Finishes
  - Cadmium, Tin, and Zinc Coatings Shall Not Be Used
- Stress Corrosion
  - Materials Shall Be Selected to Control Stress Corrosion Cracking in Accordance With, "Design Criteria for Controlling Stress Corrosion Cracking," MSFC-SPEC-522A
- Corona Suppression
  - The FAME Observatory Shall Be Designed to Minimize Corona Discharge in All Normal Operating Environments
- Nameplating and Product Marking
  - Components Shall Be Identified by Part Number and Serial Number or Lot Number

Mission Requirements (3 of 5)

3.3 Design and Construction (Continued)

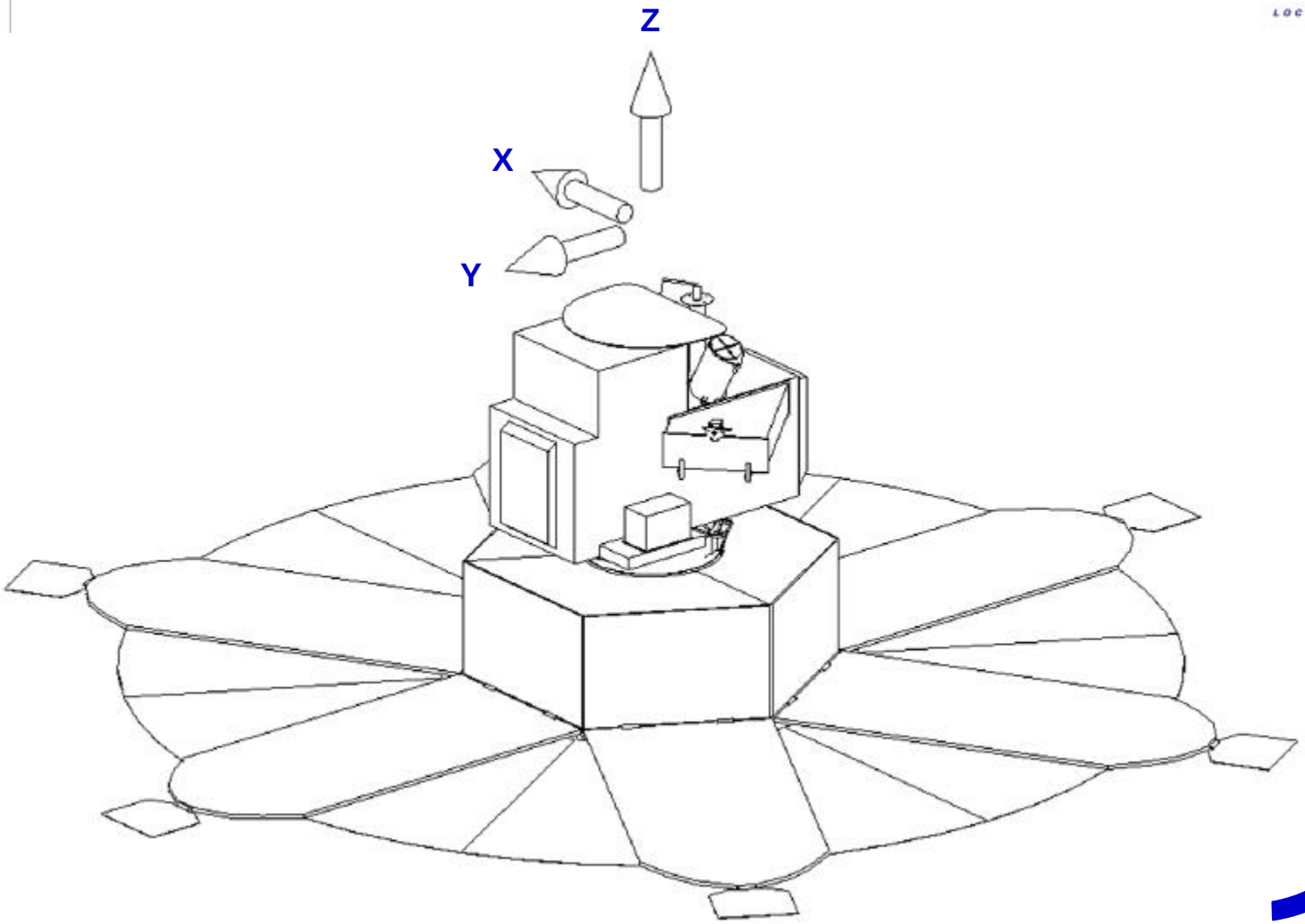
- **Safety**
  - **Design, Operation, and Testing of the FAME Observatory Space Segment and its GSE Shall Satisfy the Requirements of EWRR 127-1, Chapters 3 and 5**
- **Positive Locking Devices**
  - **Screw-Type Hardware Shall Employ Positive Locking. If used, Safety Wiring Shall be According to MS33540**
- **Drawings**
  - **Specifications and Hardware Shall be Supported by Drawings According to the Guidelines Set Forth in MIL-DTL-31000 and DOD-D-1000, or Their Supplier Equivalents**
- **Grounding**
  - **The Spacecraft Bus Shall have a Metal to Metal Impedance of 2.5 mohms or Less for the Electronics Box to Mounting Deck Interface In Addition to a Metal to Composite Impedance of 10 Ohms or Less**

Mission Requirements (4 of 5)

3.7 FAME Observatory Characteristics

- **Operational Envelope**
  - **Provide Shade from the Sun's Rays for the Spacecraft During Operational Configuration**
- **Launch Vehicle Interface**
  - **Provide a Structural Interface for the Flight Vehicle to the Launch Vehicle as Defined by the Flight Vehicle to Launch Vehicle ICD**
- **Instrument Interface**
  - **Provide a Structural Interface for the Instrument to the Spacecraft Bus As Defined by the Spacecraft Bus to Instrument ICD**
- **FAME Observatory Mass Allocation**
  - **The FAME Observatory Shall Not Exceed 1100 kg**

Mission Requirements (5 of 5)



Direction of Rotation

Figure 1 - Global Coordinate System

Derived Requirements (1 of 7)

- Levied by EPS
  - Solar Array Area
    - Provide 864.0 In^2 of Illuminated Solar Cell Area Per Array Arm
- Levied by ACS
  - Solar Array Panel Flatness
    - Provide Solar Array Panels With a Flatness of 2.5 mm Over 2 m for All Phases of the Mission
  - Sun Shade Web Flatness
    - Provide Sun Shade Web With a Flatness of 2.5 mm Over 2 m for All Phases of the Mission
  - Electronics Deck Flatness
    - Provide Electronics Decks With a Flatness of 2.5 mm Over 2 m for All Phases of the Mission
  - Sun Sensor Locations
    - Position the Sun Sensor to Provide an Unobtrusive Field of View During All Phases of the Mission
  - Trim Tab Locations
    - Position the Trim Tabs to Provide the Maximum Control Authority During the Deployed Configuration
  - Trim Mass Locations
    - Position the Trim Masses to Provide the Maximum Control Authority During the Deployed Configuration

Derived Requirements (2 of 7)

- Levied by ACS (Continued)
  - IMU Location
    - Position the IMU to Provide Shielding From Radiation. In Addition, Provide an Optical View of the Reference Retroreflector at System Integration
  - Flight Vehicle CG Offset
    - The Center of Gravity (CG) of the Flight Vehicle Shall Not Exceed TBD Inch Lateral Offset From the SRM Thrust Vector
  - Flight Vehicle Principle Spin Axis Alignment
    - The Principle Spin Axis of the Flight Vehicle Shall Not Exceed 1.5 Degree (TBR) From the SRM Thrust Vector
  - Spacecraft Lateral CG Offset
    - The Center of Gravity (CG) of the Spacecraft Shall Not Exceed 10 mm Lateral Offset From the Spacecraft's Geometric Centerline As Defined by the Spacecraft Mechanical Interface at Beginning of Life
  - Spacecraft Axial CG Location
    - The Center of Gravity (CG) of the Spacecraft Shall .8±.1m Axial Distance From the Solar Array at Beginning of Life
  - Spacecraft Principle Spin Axis Alignment
    - The Principle Spin Axis of the Spacecraft Shall Not Exceed 1.5 Degree Misalignment From the Spacecraft's Geometric Centerline As Defined by the Spacecraft Mechanical Interface at Beginning of Life
  - Spacecraft Principle Spin Axis Moment of Inertia (IZZ)
    - The Spin Moment of Inertia of the Spacecraft Shall Be 380 to 420 Kg*m^2 at Beginning of Life

Derived Requirements (3 of 7)

- Levied by ACS (Continued)
  - Spacecraft Principle Transverse Axis Moments of Inertia (Ixx & Iyy)
    - Both Transverse Moments of Inertia of the Spacecraft Shall be 89 to 91% of the Spin Moment of Inertia at Beginning of Life
  - Spacecraft Principle Transverse Axis Product of Inertia (Ixy)
    - The Transverse Product of Inertia of the Spacecraft Shall be Equal to or Less than 4.0 kg*m^2 at Beginning of Life
  - Maximum Jitter
    - TBD
- Levied by RCS
  - Propellant Fill and Drain Valve Locations
    - The Location of the Fill and Drain Valves Shall Be Easily Accessible During Integration, Test, and Field Operations Phases of the Mission
  - Thruster Locations
    - Position the Thrusters to Provide Maximum Control Authority with an Unobstructed Field of View During Thruster Operation for all Phases of the Mission
  - AKM Location
    - Position the AKM to Provide an Unobstructed Path for the Plume During SRM Operation
  - Hydrazine Mounting
    - The Structural Mount for the Hydrazine Tank Shall not be in the Load Path of the Primary Structure

Derived Requirements (4 of 7)

- **Levied by Electrical**
  - **Provide a Wire Harness Mockup for Flight Wire Harness Fabrication**
  - **The Location of the Ordnance Arm Plug and Umbilical Connections Shall Be Easily Accessible During Integration, Test and Field Operations Phases of the Mission**
  - **Position the RF Antennas to Provide an Unobstructed Field of View During All Phases of the Mission**
- **Levied by Instrument**
  - **Instrument Location**
    - **Orient the Instrument Such That the Entrance Apertures Have an Unobstructed Field of View and look 90° ± TBD Degrees From the Spin Axis During Operation Configuration**
- **Levied by Integration and Test**
  - **Provide Attachment Points and Lifting Fixture for Lifting the Flight Vehicle During Launch Vehicle Integration**

Derived Requirements (5 of 7)

Levied by Integration and Test (Continued)

- Provide Attachment Points and Lifting Fixture for Lifting the Spacecraft Bus During Integration
- Provide Attachment Points and Lifting Fixture for Lifting the Interstage Assembly During Integration
- Provide Assembly fixtures for Flight System Integration
- Provide Non-Flight Protective Covers for Solar Arrays During Ground Handling and System Integration
- Provide Solar Array Shipping Container as Defined by the Integration and Test Engineer
- Provide Non-Flight Protective Covers for Thrusters During Ground Handling and System Integration
- Provide Mass Simulators for all Major Electrical Components for System Level Testing
- Provide Mass Simulators for the Instrument for System Level Testing
- Provide a Non-Flight Alignment Cube for the Spacecraft Bus for System Integration

Derived Requirements (6 of 7)

Levied by Integration and Test (Continued)

- **Provide all Test Fixtures as Defined by the Integration and Test Engineer**
- **Provide all Ground Handling Fixtures as Defined by the Integration and Test Engineer**
- **Provide a Spacecraft Shipping Container as Defined by the Integration and Test Engineer**

Levied by Mechanical

- **Design Limit Loads**
  - **All structural Systems and Components Shall be Capable of Surviving all Loads for all Environments as Defined by the Design, Loads, and Analysis Plan, NCST-D-FM017**
- **Factors of Safety (FOS)**
  - **The Spacecraft Shall use the FOS as Defined by Table 5-1 Thru 5-3 in the Design, Loads, and Analysis Plan, NCST-D-FM017**
- **Natural Frequency**
  - **The Flight Vehicle Shall have a First Natural Frequency No Less Than that Defined in the Design, Loads and Analysis Plan, NSCT-D-FM017**
- **Hydrazine Tank Location**
  - **Position the Hydrazine Tank Such that the Depletion of Hydrazine Will have a Minimal Effect on the Lateral Location of the Center of Mass During the Life of the Mission**

Derived Requirements (7 of 7)

- **Levied by Thermal**
  - **Engineering Model**
    - **Provide an Engineering Model (EM) for Thermal Design Verification Testing (TDVT)**
  - **Radiation Surface**
    - **Provide an Electronics Deck With Enough Radiating Surface to Meet the Thermal Dissipation Needs**
- **Levied by Mechanism**
  - **Provide a Solar Array Arm Deployment Fixture as Defined by the Mechanism Subsystem**

Mechanical Design Trades

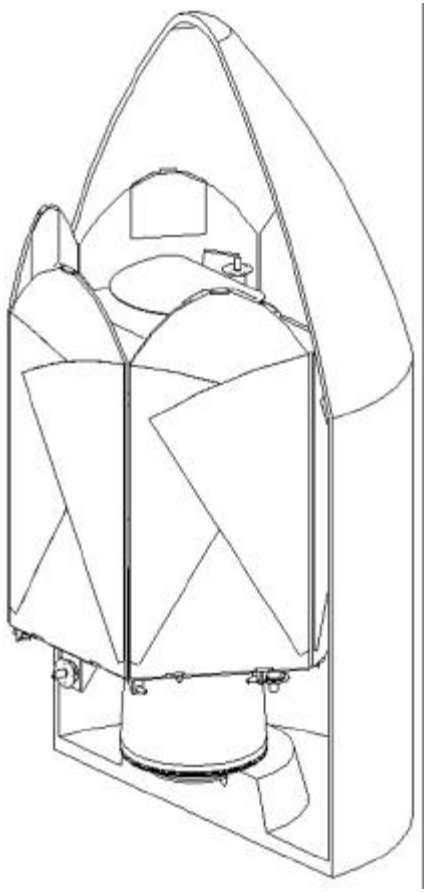
- Solar Array Design Trade
- The Primary Structure Mass Reduction Trade
- Star Tracker Location vs. Performance Trade
- Antenna Location Trade
- Trades to Minimize Thermal Distortion

Mechanical Issues and Concerns

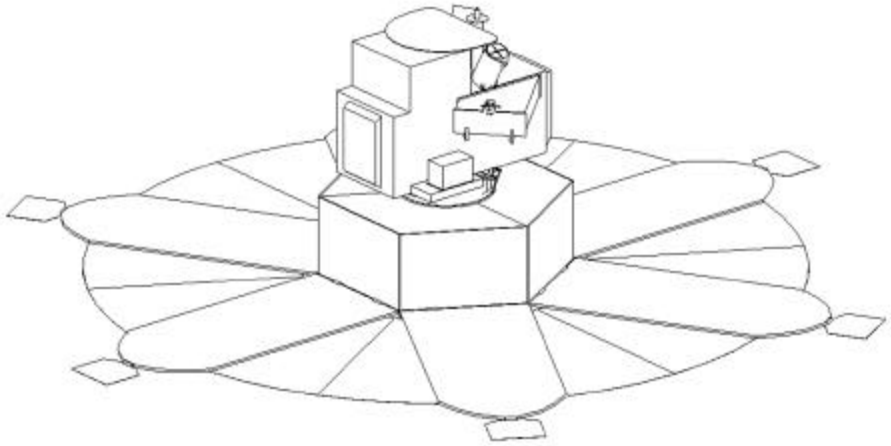
- **Principle Moments and Products of Inertia Requirements**
- **Overall Flight Vehicle Mass**
- **Definition of Center of Pressure Requirement**

Mechanical Backup Material

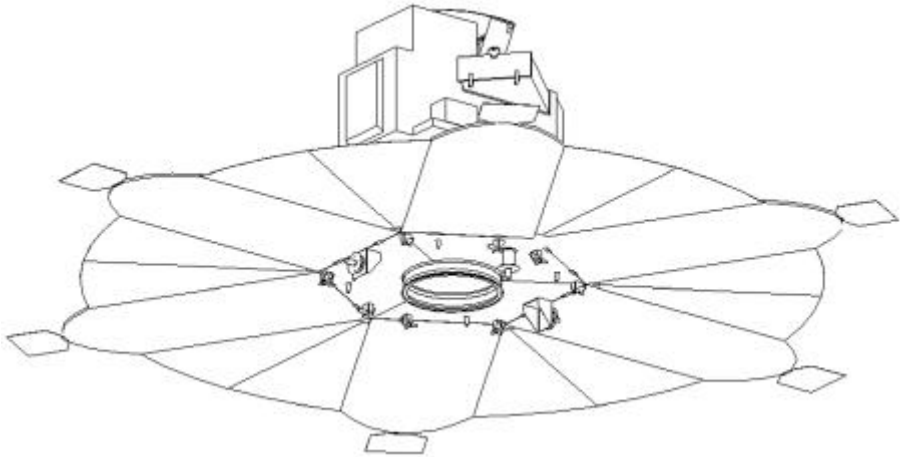
- **Current Baseline Design**



Launch Configuration



Operation Configuration



Operation Configuration